

On dragonfly nymphs (Insecta: Odonata: Anisoptera) from the caldera of the Cerro Azul volcano, Isla Isabela (Galápagos Archipelago, Ecuador)

Markus Lambertz^{1,5}, Volker Spieth², Judith Denking³ & Walter Traunspurger⁴

¹*Institut für Zoologie, Rheinische Friedrich-Wilhelms-Universität Bonn, Poppelsdorfer Schloß, 53115 Bonn, Germany*

²*Zoologisches Forschungsmuseum Alexander Koenig, Adenauerallee 160, 53113 Bonn, Germany*

³*Galápagos Academic Institute for the Arts and Sciences (GAIAS), Universidad San Francisco de Quito,
Puerto Baquerizo Moreno, Isla San Cristóbal, Galápagos, Ecuador*

⁴*Abteilung Tierökologie, Universität Bielefeld, Morgenbreede 45, 33615 Bielefeld, Germany*

⁵*Corresponding author; E-mail: lambertz@uni-bonn.de.*

Abstract. We describe nymphs of the spot-winged glider, *Pantala hymenaea*, encountered during an expedition to the caldera of the Cerro Azul volcano on Isabela island in February 2009. This faunistic shortnote provides the first species-level identification of odonates from a caldera lake of an active Galápagos volcano.

Zusammenfassung. Wir berichten über den Fund von Nymphen der Großlibelle *Pantala hymenaea* bei einer Expedition in die Caldera des Cerro Azul Vulkans auf der Insel Isabela im Februar 2009. Diese faunistische Kurzmitteilung ist der erste Nachweis von Libellen auf Artniveau aus einem Caldera See eines aktiven Galápagos Vulkans.

Key words. Caldera lake, Chironomidae, *Chironomus*, faunistics, Galápagos Islands, Libellulidae, *Pantala hymenaea*.

The odonate fauna on Galápagos is far less diverse compared to continental South America as freshwater bodies are scarce on the islands. However, adult dragonflies and damselflies (Insecta: Odonata: Anisoptera + Zygoptera) are frequently encountered and nymphs can be found in several temporary pools. Nevertheless, detailed faunistic data documenting the presence or absence of nymphs in the various water bodies are lacking (Peck 1992, 2001). For the caldera lakes of the archipelago's active volcanoes, there are only two rather anecdotal reports. Eibl-Eibesfeld (1961, cited after Peck 1992) observed nymphs in the caldera lake on Fernandina island, but gave no identification of the species. Furthermore, two unidentified aeshnid (Anisoptera: Aeshnidae) and libellulid (Anisoptera: Libellulidae) species were mentioned by Muschiol & Traunspurger (2009), endorsing Peck's (1992, 2001) speculation that nymphs could also live in the caldera of Cerro Azul on Isabela island. Here we present the first species-level identification of odonate nymphs from the caldera of this active volcano.

Located in the southwestern part of Isabela island, Cerro Azul is the second highest volcano on the Galápagos Archipelago (approximately 1690 m in elevation) and its summit is dominated by an elliptic caldera (Banfield et al. 1956). In the caldera, there are several temporary lakes, but they have been subject of only scant attention (see Table 1 for a summary of both published and previously unpublished data on these lakes). As a consequence, on-

ly a single study (focusing on the meiofauna) of their aquatic organisms is available, that of Muschiol & Traunspurger (2009). One particular lake, Cone Lake, using the name introduced by the latter authors, is about 300 m in diameter and located within a tuff cone at about 1160 m above sea level, in the caldera's northeastern corner (Fig. 1). Cerro Azul was active from May 29th and continuing through June 2008 (Smithsonian Institution 2008), about five years after the first biological data were collected, resulting in the burial or drying out of two of the lakes present in 2003. However, Cone Lake persisted and its macrobenthos was examined qualitatively in the present study.

We ascended to the summit on February 17, 2009 and reached Cone Lake during the morning of the following day. During our survey in 2009, the lake's water line, as indicated by the more prominently protruding islets (Fig. 2), appeared to be approximately two meters lower than in 2003 (see Muschiol & Traunspurger 2009: fig. 1). Samples were taken from the shore with a handheld sieve at ten sites located relatively equidistant from each other. The collected specimens were stored in 70% ethanol and examined using a dissecting microscope.

Dragonfly nymphs were captured at all ten sites. The 42 collected specimens ranged from 3 to 24 mm in size and belonged to a single species. In accordance with the key provided by House (2001) as a taxonomic reference, all nymphs were classified as Libellulidae (Insecta: Odonata), because of their spoon-shaped prementum. The



Figs 1. The caldera of the Cerro Azul volcano. View from its rim in north-eastern direction with Cone Lake in the center of the photo. Note the massive black lava field on the caldera's floor and the protective tuff cone harboring the lake. The white asterisk on the silhouette of the archipelago in the upper left corner indicates its geographic location. Photo: M. Lambertz.

absence of dorsal hooks on their abdominal segments, an epiproct not shorter than the paraprocts and lateral spines of the 9th abdominal segment not extending as far as the tips of the cerci formed the basis of further assignment of these nymphs to the genus *Pantala* Hagen, 1861. A slightly downward curved epiproct and a base of the lateral spine of the 9th abdominal segment larger than one third of its length confirmed the nymphs as belonging to the species *Pantala hymenaea* (Say, 1839).

This species, the spot-winged glider, shows a wide distribution ranging south from southern Argentina northwards to southern Canada, with occasional reports even from Alaska (Paulsen 2009). It has also been reported on Isabela island, where it is known to breed in temporary pools including brackish water habitats (Peck 1992, 2001). This, at least for odonates, highly unusual physiological tolerance is shared by most of the species found on the archipelago (Peck 2001) and may explain its presence as well in habitats like Cone Lake with its rather extreme water chemistry (see Muschiol & Traunspurger 2009 for details).

During the survey at Cone Lake, we also encountered several adult dragonflies around the lake, but were unable to catch one and thus cannot provide a reliable identification. Besides the odonates, individuals belonging to at least two species of chironomid larvae (Insecta: Diptera: Chironomidae) were observed during a qualitative macroscopic examination of the benthos. Based on mentum morphology and the relative position of the ventromental plates (see Ferrington et al. 2008: fig. 26.186), some of them could be assigned to the genus *Chironomus* Meigen, 1803, while others remained unidentified. Chironomids are known to occur in virtually every type of aquatic habitat (Pinder 1995) and are suitable and attractive prey for nymphs of the spot-winged glider (Quiroz-Martínez et al. 2005).

The fate of the aeshnid species noted in 2003 by Muschiol & Traunspurger (2009) is unclear. That the absence of this species in our most-recent sample from 2009 is a consequence of the latest eruptions in 2008 remains speculative. Moreover, it is uncertain whether *P. hymenaea* is indeed the unidentified libellulid species reported in that



Figs 2. Cone Lake from within the tuff cone. The degree of visibility of the cone-shaped islet in the center can be used to estimate the lake's water level. View is in western direction. Photo: M. Lambertz.

earlier study, although this appears to be the case. Nevertheless, as data on the odonate fauna of the archipelago are very scarce, especially regarding their potential presence in the various water bodies, our report contributes to the documentation of both the islands' and this species' natural history.

Acknowledgements. The Parque Nacional Galápagos (PNG) provided the research and collection permit (PC- 04-09). We thank all the members of the expedition, Hubert Spieth, Kai Ristau (Bielefeld), Nicole Spann (Cambridge), Felipe Campos and Jenny Quijozaca (Puerto Baquerizo Moreno) for contributing to the wonderful time in the field. Special thanks go to our PNG guide Novalino, who led us down the caldera. Bradley J. Sinclair (Ottawa) is thanked for his help with chironomid identification and Tui De Roy (Golden Bay) and Michael Lang (Washington, DC) for providing information on the presence or absence of lakes in the caldera. The field work was supported by the Deutsche Forschungsgemeinschaft TR 445/7-1.

REFERENCES

- Banfield AF, Behre Jr CH, Clair DS (1956) Geology of Isabela (Albemarle) Island, Archipelago de Colon (Galapagos). *Bulletin of the Geological Society of America* 67: 215–234
- Eibl-Eibesfeld I (1961) Galápagos, the Noah's ark of the Pacific. Doubleday and Co, Garden City, New York.
- Ferrington Jr LC, Berg MB, Coffman WP (2008) Chironomidae. pp. 847–989 in: Merritt RW, Cummins KW, Berg MB (eds.) *An Introduction to the Aquatic Insects of North America*. 4th ed., Kendall/Hunt Publishing Co., Dubuque, Iowa
- Hagen H (1861) Synopsis of the Neuroptera of North America, with a list of the South American species. *Smithsonian Miscellaneous Collections* 4:1–347
- House NL (2001) Key to nymphs and nymphal exuviae of Galápagos Anisoptera. pp. 118–119 in: Peck SB: *Smaller Orders of Insects of the Galápagos Islands, Ecuador: Evolution, Ecology and Diversity*. NRC Research Press, Ottawa, Ontario
- Jackson MH (1993) *Galápagos – A natural history*. Revised and expanded edition. University of Calgary Press, Calgary, Alberta
- McBirney AR, Williams H (1969) Geology and petrology of the Galápagos Islands. *Geological Society of America Memoir* 118: 1–197

- Meigen JW (1803) Versuch einer neuen Gattungs-Eintheilung der europäischen zweiflügligen Insekten. *Magazin für Insektenkunde* 2: 259–281
- Munro DC, Rowland SK (1996) Caldera morphology in the western Galápagos and implications for volcano eruptive behavior and mechanisms of caldera formation. *Journal of Volcanology and Geothermal Research* 72: 85–100
- Muschiol D, Traunspurger W (2009) Life at the extreme: meiofauna from three unexplored lakes in the caldera of the Cerro Azul volcano, Galápagos Islands, Ecuador. *Aquatic Ecology* 43: 235–248
- Naumann T, Geist D (2000) Physical volcanology and structural development of Cerro Azul Volcano, Isabela Island, Galápagos: implications for the development of Galápagos-type shield volcanoes. *Bulletin of Volcanology* 61: 497–514
- Paulson D (2009) Dragonflies and Damselflies of the West. Princeton University Press, Princeton and Oxford
- Peck SB (1992) The Dragonflies and Damselflies of the Galápagos Islands, Ecuador (Insecta: Odonata). *Psyche* 99: 309–321
- Peck SB (2001) Smaller Orders of Insects of the Galápagos Islands, Ecuador: Evolution, Ecology and Diversity. NRC Research Press, Ottawa, Ontario
- Pinder LCV (1995) The habitats of chironomid larvae. pp. 107–135 in: Armitage PD, Cranston PS, Pinder LCV (eds.) *The Chironomidae: Biology and ecology of non-biting midges*. Chapman & Hall, London
- Quiroz-Martínez H, Rodríguez-Castro VA, Solís-Rojas C, Maldonado-Blanco MG (2005) Predatory capacity and prey selectivity of nymphs of the dragonfly *Pantala hymenaea*. *Journal of the American Mosquito Control Association* 21: 328–330
- Say T (1839) Descriptions of New North American Neuropterous Insects, and Observations on some already described. *Journal of the Academy of Natural Sciences of Philadelphia* 8: 9–46
- Simkin T (1984) Geology of Galápagos Islands. pp. 15–41 in: Perry R (Ed.): *Galápagos (key environments)*. Pergamon Press, Oxford
- Smithsonian Institution (2008) Cerro Azul. *Bulletin of the Global Volcanism Network* 33

APPENDIX

Table 1. Summary of published and unpublished data on lakes in the caldera of the Cerro Azul volcano.

Date	Cone Lake present	Main Lake present	Source	Comments
1946	no	no	McBirney & Williams 1969	Due to the presence of the tuff cone at that time and the formation processes of such cones (Simkin 1984), it can be assumed that water had been temporarily present within the caldera prior to 1946.
December 1972	no	no	T De Roy, Golden Bay, pers. comm. 2011	
April 1974	no	no	T De Roy, Golden Bay, pers. comm. 2011	
early 1980	no	no	T De Roy, Golden Bay, pers. comm. 2011	
June 1983	yes	yes	T De Roy, Golden Bay, pers. comm. 2011	A huge El Niño event affected the Galápagos between December 1982 and July 1983 (Jackson 1993). On the SPOT image (fig. 6a), even though not entirely unambiguous, there appears to be water also in the tuff cone.
1988/89	?	yes	Munro & Rowland 1996	
1991	yes	yes	Naumann & Geist 2000	
summer 1993	yes	yes	Naumann & Geist 2000	
summer 1995	yes	no	Naumann & Geist 2000	
1998	yes	yes	Naumann & Geist 2000	Cone Lake was nearly full.
June 1998	yes	yes	M Lang, Washington, DC, pers. comm. 2011	Confirmation of a relatively high water level for Cone Lake.
February 2003	yes	yes	Muschiol & Traunspurger 2009	A small “Side Lake” was isolated from the Main Lake.
June 2008	yes	no	T De Roy, Golden Bay, pers. comm. 2011	Cerro Azul was active at that time. The water level of Cone Lake was lower than in 2003.
February 2009	yes	no	this study	The water level of Cone Lake was comparable to that in 2008.